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PTO/SB/05 (4/98)

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UTILITY PATENT APPLICATION TRANSMITTAL <small>(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))</small>	Attorney Docket No. 10619RNU02U;1273/19
	First Inventor or Application Identifier Ress et al.
	Title See 1 in Addendum
	Express Mail Label No. EJ165916448US

APPLICATION ELEMENTS See MPEP chapter 600 concerning utility patent application contents.	ADDRESS TO: Assistant Commissioner for Patents Box Patent Application Washington, DC 20231
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1. <input checked="" type="checkbox"/> * Fee Transmittal Form (e.g., PTO/SB/17) <small>(Submit an original and a duplicate for fee processing)</small>	
2. <input checked="" type="checkbox"/> Specification <small>[Total Pages 52]</small> <small>(preferred arrangement set forth below)</small>	
- Descriptive title of the Invention - Cross References to Related Applications - Statement Regarding Fed sponsored R & D - Reference to Microfiche Appendix - Background of the Invention - Brief Summary of the Invention - Brief Description of the Drawings (if filed) - Detailed Description - Claim(s) - Abstract of the Disclosure	
3. <input checked="" type="checkbox"/> Drawings(s) (35 U.S.C. 113) <small>[Total Sheets 20]</small>	
4. Oath or Declaration <small>[Total Pages 4]</small>	
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5969/60/60
1-042

Attachment to PTO/SB/05 (4/98) Utility Patent Application
Transmittal

1. METHOD AND APPARATUS FOR INTERWORKING BETWEEN INTERNET
PROTOCOL (IP) TELEPHONY PROTOCOLS

3542 U.S. PTO

09/506945



02/18/00

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Natalie R. Reid

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Assistant Commissioner for Patents
BOX PATENT APPLICATION
Washington, D.C. 20231

Re: U.S. Patent Application for METHOD AND APPARATUS FOR
INTERWORKING BETWEEN INTERNET PROTOCOL (IP) TELEPHONY
PROTOCOLS
Our Ref. No. 10619RNU02U:1273/19

Sir:

Please find enclosed the following:

1. A U.S. patent application for METHOD AND APPARATUS FOR
INTERNETWORKING BETWEEN INTERNET PROTOCOL (IP)
TELEPHONY PROTOCOLS (52 pages of specification);
2. A Utility Patent Application Transmittal Form (Form PTO/SB/05, 2 pages);
3. A Fee Transmittal Form (Form PTO/SB/17);
4. Twenty (20) sheets of drawings;
5. Executed Declaration;
6. Executed Assignment and Recordation Cover Sheet;
7. A Preliminary Amendment (2 pages);
8. A check in the amount of \$1042.00 to cover the \$1002.00 application filing

Assistant Commissioner for Patents
February 18, 2000
Page 2

fee and \$40.00 Assignment recordation fee;

9. A return-receipt postcard to be returned to our offices with the U.S. Patent and Trademark Office date stamp thereon; and
10. A Certificate of Express Mail No.: EJ165916448US.

Please contact our offices if there are any questions.

Respectfully submitted,

JENKINS & WILSON, P.A.



Jeffrey L. Wilson
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JLW/GAH/ajm

Enclosures

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Natalie R. Reid

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Ress et al.

Examiner: Unassigned

Serial No.: Unassigned

Group Art Unit: Unassigned

Filed: Herewith

Docket No.: 1273/19

For: METHOD AND APPARATUS FOR INTERWORKING BETWEEN INTERNET
PROTOCOL (IP) TELEPHONY PROTOCOLS

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

Sir:

AMENDMENTS

Please amend the subject application as follows:

IN THE SPECIFICATION:

Please amend the specification as follows:

Page 17, line 25, please change "code" to --codec--.

Page 41, line 8, after "message." please insert --The remaining messages in Figure 19 are similar to the messages described with respect to lines 1-4 of the call flow diagram. Hence, a description thereof is not repeated herein.--

IN THE CLAIMS:

Please amend the claims as follows:

In claim 5, line 4, please delete "Bellcore";

line 5, please delete "Bellcore".

In claim 32, line 3, please delete "Bellcore".

REMARKS

The above amendments improve the form of the application without adding any new matter.

Respectfully submitted,

JENKINS & WILSON, P.A.

Date: 18 Feb. 2000

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Natalie P. Reid
Natalie P. Reid

METHOD AND APPARATUS FOR INTERWORKING BETWEEN INTERNET
PROTOCOL (IP) TELEPHONY PROTOCOLS

AN APPLICATION FOR
UNITED STATES LETTERS PATENT

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Description

METHOD AND APPARATUS FOR INTERWORKING BETWEEN INTERNET PROTOCOL (IP) TELEPHONY PROTOCOLS

5

Priority Application

This Application claims the benefit of U.S. Provisional Patent
Application Serial No. 60/137,867 filed June 7, 1999, the disclosure of which
is incorporated herein by reference in its entirety.

10

Technical Field

The present invention relates to a method and an apparatus for
interworking between communications protocols. More particularly, the
present invention relates to a method and an apparatus for interworking
15 between internet protocol (IP) telephony protocols.

Background Art

There are a variety of known protocols for establishing media stream
communications, such as voice, data, video, or combinations thereof, over
20 an IP network. Protocols for establishing media stream communications
over an IP network are referred to herein as IP telephony protocols. One
example of an IP telephony protocol is the media gateway control protocol
(MGCP). MGCP defines signals and events by which a software entity,

known as a media gateway (MG), is controlled by another software entity, known as a media gateway controller (MGC), in a packet network. The media gateway controller processes call control signaling from one or more signaling gateways (SGs) and utilizes MGCP media control signaling to
5 establish media streams between MGs. An MGC that processes call control signaling in this manner is also referred to as a call agent. The terms media gateway controller and call agent are used interchangeably herein. The media gateway controller performs call control functions, such as translations, resource management, media capabilities negotiation and
10 selection, and media stream management. It can also provide additional services.

Figure 1 illustrates conventional communications using MGCP. In Figure 1, MGC **100** receives call signaling information from SGs **102** and **103** and controls MGs **104** and **105** to establish packetized media stream
15 communications between end users in packet network **106**. For example, SG **102** and MG **104** can be associated with a calling party end user device for a given media stream communication. Similarly, SG **103** and MG **105** can be associated with a called party end user device for a given media stream communication. MGC **100** can control MGs **104** and **105** to establish
20 media stream communications between the called and calling end user devices, such as PSTN terminals.

A detailed explanation of MGCP is found in Media Gateway Control Protocol (MGCP), Version 0.1 Draft, Internet Engineering Task Force, February 21, 1999, the disclosure of which is incorporated herein by
25 reference in its entirety.

Another example of an IP telephony protocol is International Telecommunications Union (ITU) Recommendation H.323. H.323 defines a protocol by which endpoints, such as gateways, terminals, or multipoint control units (MCUs), can place calls in a packet network. A gateway
5 translates between circuit-switched and packet-switched communication protocols. A terminal is a device, such as an IP terminal, that provides end user access to a network. An MCU is a device that supports conferences between three or more endpoints. H.323 defines a gatekeeper as an entity that provides address translation and controls access to the packet network
10 for H.323 endpoints. The gatekeeper can also provide additional services, such as call control and supplementary services.

Figure 2 illustrates an example of conventional H.323 communications. In Figure 2, a first gateway **200** can be associated with a calling end user device and a second gateway **202** can be associated with a
15 called end user device for a given media communication. Gatekeeper **204** performs call signaling functions, such as call setup and teardown, to establish calls between end user devices associated with gateways **200** and **202**. The end user devices can be PTSN terminals connected to gateway **200**. Alternatively, gateway **200** can be omitted and replaced by H.323
20 terminals or H.323 MCUs. Once gatekeeper **204** performs the call signaling functions necessary to set up a call, the media stream for the call flows between gateways **200** and **202**. Detailed information relating to H.323 can be found in ITU Recommendation H.323, Packet Based Multimedia Communications Systems, February 1998, the disclosure of which is
25 incorporated herein by reference in its entirety.

Yet another IP telephony protocol is ITU Recommendation H.248. The Internet Engineering Task Force (IETF) formed the MEGACO Group to evolve the MGCP protocol. As the MEGACO Group matured the protocol, the MEGACO Group allied itself with the ITU, and the specification
5 developed by the MEGACO Group has become known as ITU Recommendation H.248. Thus, ITU recommendation H.248 can be viewed similarly to MGCP.

Another IP telephony protocol is the session initiation protocol (SIP). SIP is an application layer signaling protocol for creating, modifying, and
10 terminating sessions between one or more participants. The sessions include internet multimedia conferences, internet telephone calls, and multimedia distribution. SIP originated from Columbia University and is gaining acceptance as a protocol for exchanging call signaling information over a packet network. A detailed description of SIP can be found in
15 Request for Comments (RFC) 2543 SIP: Session Initiation Protocol, March 1999, the disclosure of which is incorporated herein by reference in its entirety.

In addition to the published protocols described above, many vendors of telecommunications equipment and services are supporting IP telephony
20 applications via proprietary protocols.

All of the IP telephony protocols described above are being implemented by various vendors. However, standards for interworking equipment that communicates using one protocol with equipment that communicates using another protocol are immature, nonexistent, or focus
25 only on a specific type of application. Accordingly, there exists a long-felt

need for a novel method and apparatus for interworking between IP telephony protocols.

Disclosure of the Invention

5 The present invention provides a novel method and apparatus for interworking between IP telephony protocols. Although most of the examples described below relate to MGCP and H.323, it is understood that the method and apparatus described herein are applicable to any IP telephony protocol.

10 Many of the protocols described herein define an entity that is responsible for performing functions and requests on behalf of a telephony device. Typically, these functions and requests include translations, media capabilities exchange, and other services. The entities that perform the functions can be logical, physical, or both. For example, in MGCP, the MGC
15 or call agent performs call signaling functions on behalf of a gateway. In H.323, the gatekeeper performs call signaling functions for an H.323 gateway. In SIP, a proxy server performs call signaling functions for an end user. In order to facilitate a description of the present invention, the term call server is used herein to refer to an entity that performs call signaling
20 functions, such as translations and media capabilities exchange, on behalf of an end user device, gateway, or other entity.

 According to a first aspect, the present invention includes a call server including a first protocol agent and a second protocol agent. The first protocol agent communicates with a first protocol device according to a first
25 protocol. The second protocol agent communicates with a second protocol

device according to a second protocol. An interworking agent provides functions usable by the first and second protocol agents to communicate using a third protocol. The third protocol provides a superset of the functions provided by the first and second protocols.

- 5 Accordingly, it is an object of the present invention to provide a novel method and apparatus for interworking between IP telephony protocols.

 An object of the invention having been stated hereinabove, and which is achieved in whole or in part by the present invention, other objects will be evident as the description proceeds, when taken in connection with the
10 accompanying drawings as best described hereinbelow.

Brief Description of the Drawings

A description of the present invention will now proceed with reference to the accompanying drawing of which:

- 15 Figure 1 is a block diagram illustrating conventional MGCP network entities;

 Figure 2 is a block diagram illustrating conventional H.323 network entities;

- Figure 3 is a block diagram illustrating media gateway controller and
20 gatekeeper functions implemented within a call server according to an embodiment of the present invention;

 Figure 4 is a block diagram illustrating a call server wherein each call half is represented by an agent according to an embodiment of the present invention;

Figure 5 is a block diagram illustrating a call server including a plurality of interworking agents according to an embodiment of the present invention;

Figure 6 is a block diagram illustrating protocol agents implementing
5 originating and terminating call half functions executing on different machines wherein an interworking agent is associated with each protocol agent;

Figure 7 is a block diagram illustrating a call server including MGCP, interworking, and H.323 agents for interworking MGCP and H.323 entities
10 according to an embodiment of the present invention;

Figure 8 is a block diagram illustrating a connection information parameter data structure according to an embodiment of the present invention;

Figures 9(a) and 9(b) are flow charts illustrating message tunneling
15 according to an embodiment of the present invention;

Figure 10 is a block diagram illustrating exemplary agent interworking protocol message structures according to an embodiment of the present invention;

Figure 11 is a block diagram illustrating an exemplary data structure
20 for a digit information parameter according to an embodiment of the present invention;

Figure 12 is a call flow diagram illustrating exemplary call signaling for H.323 fast start to MGCP communications according to an embodiment of the present invention;

Figure 13 is a call flow diagram illustrating H.323 non-fast-start to MGCP communications according to an embodiment of the present invention;

Figure 14 is a call flow diagram illustrating exemplary call signaling for a hold scenario between H.323 and North American Q.931 endpoints according to an embodiment of the present invention;

Figure 15 is a call flow diagram illustrating exemplary call signaling for a retrieve scenario between H.323 and North American Q.931 endpoints according to an embodiment of the present invention;

Figure 16 is a call flow diagram illustrating exemplary call signaling for a hold scenario between H.323 and MGCP endpoints according to an embodiment of the present invention;

Figure 17 is a call flow diagram illustrating exemplary call signaling for a retrieve scenario between H.323 and MGCP endpoints according to an embodiment of the present invention;

Figure 18 is a call flow diagram illustrating exemplary call signaling between H.323 and MGCP endpoints for common channel signaling according to an embodiment of the present invention; and

Figure 19 is a call flow diagram illustrating exemplary call signaling between an MGCP gateway and an H.323 gateway according to an embodiment of the present invention.

Detailed Description of the Invention

The present invention provides a novel method and apparatus for interworking between IP telephony protocols. In order to provide this

interworking, a call server includes agents that communicate with other entities according to the protocols implemented by the other entities. However, the protocol agents communicate with each other utilizing a protocol-independent agent interworking protocol (AIP). As a result, network entities that implement different protocols can seamlessly communicate with each other.

Figure 3 illustrates a call server including MGC and GK functions according to an embodiment of the present invention. In Figure 3, a call server 300 includes an MGC function 302 and a GK function 303. The call server is a software entity that can execute on a single machine or on multiple machines. MGs and SGs recognize call server 300 as an MGC. H.323 endpoints, such as gateways, recognize call server 300 as a GK. For example, in the illustrated embodiment, ingress MG 304, egress MG 306, and SG 308 recognize call server 300 as an MGC. Similarly, ingress H.323 gateway 310 and egress H.323 gateway 312 recognize call server 300 as a gatekeeper.

In order for MGs 304 and 306 to recognize call server 300 as an MGC, MGC function 302 in call server 300 is adapted to communicate with MGs 304 and 306 using MGCP. Similarly, in order for SG 308 to recognize call server 300 as an MGC, MGC function 302 in call server 300 communicates with SG 308 using a call signaling protocol, such as ISDN Part (ISUP). In order for H.323 gateways 310 and 312 to recognize call server 300 as a gatekeeper, gatekeeper function 303 in call server 300 communicates with gateways 310 and 312 according to ITU Recommendations H.225 and H.245.

Figure 4 illustrates an embodiment of call server **300** in which the call processing functions illustrated in Figure 3 are separated into call agents, each of which performs call half functions. As used herein, call half functions refer to functions associated with either the originating or terminating side of a call. For example, in Figure 4, MGCP function **302** illustrated in Figure 3 is divided into MGCP agent **302A** and MGCP agent **302B**. Similarly, H.323 function **303** illustrated in Figure 3 is divided into H.323 agent **303A** and H.323 agent **303B**. MGCP agent **302A** and H.323 agent **303A** can perform call originating functions, such as collection of digits and translations. MGCP agent **302B** and H.323 agent **303B** can perform call terminating functions, such as trunk selection and alerting the called party of an incoming call. The functions performed by each call half will be explained in detail below with reference to call flow diagrams.

As mentioned above, the present invention is not limited to interworking between MGCP and H.323 entities. For example, Figure 5 illustrates a call server including protocol agents configured to communicate with other agents using a variety of different protocols. In the illustrated embodiment, call server **300** includes MGCP agents **302A** and **302B** for processing MGCP to MGCP calls, H.323 agents **303A** and **303B** for processing H.323 to H323 calls, H.323 agent **500A** and MGCP agent **500B** for processing H.323 to MGCP calls, H.323 agent **502A** and SIP agent **502B** for processing H.323 to SIP calls, and H.323 agent **504A** and NAQ.931 agents **504B** for processing H.323 to NAQ.931 calls. In addition, to the protocol agents, call server **300** also includes an interworking agent **506** which facilitates communication between protocol agents. More particularly,

interworking agent **506** includes methods for getting and setting AIP parameters, building AIP messages, and establishing and maintaining connections, such as TCP or reliable UDP connections, between protocol agents. Interworking agents can also identify AIP message types, which will
5 be described in more detail below. Thus, as illustrated in Figure 5, interworking agent **506** provides functions usable by a variety of different protocol agents to provide seamless interworking between the protocol agents.

In a preferred embodiment of the invention, the interworking agent is
10 divided into separate software components, one component associated with the protocol agent for each call half. The division of the interworking agent into two software components allows protocol agents associated with a given call to execute on separate machines.

Referring to Figure 6, call server **300** illustrated in Figure 5 is divided
15 into call servers **300A**, **300B**, and **300C**, which can execute on the same machine or on different machines. Call server **300A** includes protocol agents that perform both originating and terminating call half functions. Call servers **300B** and **300C** each include protocol agents that perform only originating or terminating call half functions. This division of call processing functionality is
20 enabled by interworking agents components **506A** and **506B**, which enable protocol agents to communicate with each other using AIP messaging. Exemplary information that can be exchanged using AIP messaging includes information regarding call progress, media capabilities and addresses, supplementary services, etc. By allowing the protocol agents to reside on

separate machines, the interworking agents according to embodiments of the present invention allow efficient division of call processing functions.

Figure 7 illustrates an example of an MGCP-H.323 network typology wherein communication between MGCP and H.323 endpoints occurs through a call server according to an embodiment of the present invention. In Figure 7, call server **300** includes MGCP agent **700A** for performing originating call half functions according to the media gateway control protocol and H.323 agent **700B** for performing terminating call half functions according to the H.323 protocol. More particularly, MGCP agent **700A** communicates with ingress media gateway **304** according to the media gateway control protocol and with signaling gateway **306** according to a call signaling protocol, such as ISUP. H.323 agent **700B** communicates with H.323 gateway **312** according to H.225 and H.245 protocols. MGCP agent **700A** and H.323 agent **700B** communicate with each other using AIP messaging. Interworking agent components **702A** and **702B** provide the functions that protocol agents **700A** and **700B** use to formulate and process AIP messages.

Because the interworking agent components **702A** and **702B** provide functions for converting messages to and from a protocol independent format, MGCP agent **700A** and the H.323 agent **700B** need not be aware of each other's protocol. Similarly, MG **304** and SG **306** need not be aware of the protocol of H.323 gateway **312**, and H.323 gateway **312** need not be aware of the protocol of MG **304** and SG **306**.

Agent Interworking Protocol

As stated above, interworking agents according to embodiments of the present invention communicate with each other according to a protocol independent format referred to as the agent interworking protocol. The agent interworking protocol is preferably capable of representing a reasonable superset of the messaging capabilities of all protocols to be supported within the packet network. Designing an interworking protocol that supports all of the capabilities of all of the supported protocols is an unnecessarily burdensome task since some capabilities are rarely used or are only useful when communicating between devices that support the particular protocol. In addition, these rarely used capabilities can be communicated between agents that support these capabilities using tunneling, as will be described in more detail below. Accordingly, it is desirable that the agent interworking protocol provide a reasonable superset of the capabilities of supported protocols.

Rather than designing an entirely new protocol for use as the agent interworking protocol, it is more desirable to select an existing protocol that comes close to meeting the superset definition described above and extending that protocol. Existing protocols that could be used as the base protocol for the agent interworking protocol include Q.931, ISUP, and SIP. The agent interworking protocol implemented in interworking agents according to preferred embodiments of the present invention is based upon ISUP. For example, AIP includes traditional ISUP messages such as initial address messages (IAM), answer messages (ANM), and release messages (REL). The agent interworking protocol extends the base protocol to include

additional procedures and signaling required to meet interoperability requirements. The functions and data structures used in the agent interworking protocol to meet these requirements will now be discussed in more detail.

- 5 One function that must be provided by the agent interworking protocol is a method for exchanging media capabilities between protocol agents. Each of the agent protocols to be interworked provide some means by which a telephony device can make known the media capabilities that it supports. These capabilities must be exchanged between two devices that desire to
10 participate in a media stream communication in order to select a mutually compatible media session definition.

Capabilities Exchange Between H.323 Devices

- H.323 allows an endpoint to advertise its capabilities at two different times - during call establishment and after call establishment. For example,
15 some H.323 devices support fast start capabilities which allow a partial list of media capabilities to be exchanged in H.225 call establishment messages. This method of exchanging capabilities allows faster establishment of a media stream between endpoints because capabilities are exchanged during call signaling, rather than waiting until after call signaling has been
20 completed. In order to exchange capabilities after call establishment, H.323 compliant devices use H.245 signaling to provide a full description of all media capabilities supported.

Capabilities Exchange Between MGCP and SIP Devices

- MGCP and SIP support the use of the session description protocol
25 (SDP) for encoding the capabilities supported by the device. The session

description protocol is included in call establishment messages similarly to H.323 fast start messages. For example, a SIP call establishment message, such as an INVITE message, includes an SDP portion in the body of the message. The SDP portion includes the capabilities supported by the endpoint, such as encoding and decoding algorithms, type of media stream, etc.

Because these capabilities can be exchanged during call setup or after call establishment, the agent interworking protocol implemented in call servers according to embodiments of the present invention is preferably flexible enough to support capabilities exchange at either time. In addition, because each of the above-mentioned protocols uses different syntax for specifying the capability's definition, AIP preferably provides a normalized syntax to which interworking agents can map the capability's definitions.

Media Management

In addition to providing a method for exchanging media capabilities, the agent interworking protocol preferably also provides media management capabilities that include a reasonable superset of the media management capabilities of supported protocols. For example, each of the agent protocols provide support for establishing and altering media streams; however, the specific protocols vary significantly. H.323 fast start procedures allow H.323 devices to establish a media stream in concert with call establishment. However, fast start is optional and might not be supported by a given H.323 device. H.245 procedures allow H.323 devices to open and close media channels post call establishment. H.323 is very limited in its ability to alter a media stream once established. H.323 media

streams can be unidirectional or bi-directional. Voice/audio media is typically represented via two independent unidirectional streams on IP networks with bi-directional media being typically used for data or for voice on ATM networks.

- 5 MGCP supports establishment of media streams during call establishment similar to H.323 fast start procedures. Media streams can be either unidirectional or bi-directional and can be changed from one format to the other at any time during a call. MGCP allows media channels to be modified in a variety of ways without having to be closed. For example, a
- 10 media stream can be redirected by changing the receiving real time protocol (RTP) address. The encoding format can be changed by changing the codec. The mode can be changed to send only, send receive, receive only, or inactive. SIP is similar to MGCP in its ability to modify media streams.

- In order to provide an interworking solution that accommodates these
- 15 agent protocols, three design objectives are preferably met. The first design objective is that the agent interworking protocols must provide sufficient flexibility to meet the requirements of all agent protocols. Second, the agent design preferably maps between agent specific and AIP procedures and syntax for media management. The third objective is that a flexible control
- 20 framework is preferably implemented that allows the agent to easily react to media changes made by the agent implementing the other call half. The connection information parameter illustrated in Figure 8 is the mechanism provided by the agent interworking protocol for implementing media management functions and exchanging media capabilities. The times for
- 25 exchanging media capabilities and performing media management functions

according to the agent interworking protocol will be described in more detail below with respect to the call flow diagrams.

Figure 8 is a table illustrating exemplary fields and field values for the connection information parameter according to an embodiment of the present invention. In Figure 8, the left hand column represents the fields in the connection information parameter data structure. The right hand column represents example values for each of the fields in the left hand column. In the illustrated embodiment, the connection information parameter includes a media type field **800** that holds a media type value **802** for specifying the type of media being exchanged or sought to be exchanged in a media stream. Example values for the media type field include audio, video, and data. Channel ID field **804** includes an internally assigned channel ID value that allows an interworking agent to identify the media stream. In the illustrated embodiment, 12345 is given as an example value **806** for channel ID field **804**. Channel operation field **808** includes a channel operation value **810** for specifying the operation being performed on the media stream. Values **810** for the channel operation field **808** are preferably a superset of protocol media stream operations for the supported protocols. In the illustrated embodiment, exemplary values for the channel operation field are no action, open, close, modify, mode change, redirect, direct, and send capabilities. The no action value indicates that no change is being made to the existing media stream. The open value specifies that a media stream is sought to be opened. The close value indicates that an open media stream is sought to be closed. The modify value indicates that the media stream is sought to be modified, e.g., changing a code from G.711 to G.729a. The

mode change value indicates that the mode of the media stream is sought to be changed, e.g., from send only to receive only. The redirect value indicates that the media stream is to be redirected to another endpoint. The direct value specifies the location to which the media stream is to be directed. The send capabilities value requests the receiving entity to transfer the media capabilities list.

Current media description field **812** stores current media description value **814** for indicating the description of the current media stream. In the illustrated embodiment, an example of a current media description value is

G.711 at two frames per packet. Media capabilities field **816** includes media capabilities value or values **818** that allows an entity to exchange its media capabilities with another entity. In the illustrated example, the media capabilities field includes a list of supported formats, such as G.711, G.729. Media capabilities field **818** also includes a payload size value that specifies the size of media capabilities field. Media capabilities field **818** also includes a redefinable area in which information specific to the type of media and codes can be specified. For example, a facsimile media stream requires certain attributes that are not required for other media types. The redefinable area allows this information to be specified.

Message Tunneling

As described above, the agent interworking protocol represents a reasonable superset of the agent protocols sufficient to achieve interworking. However, the agent interworking protocol is not a complete superset of the supported protocols. That is, certain agent protocols can contain messages or parameters which do not map to any other agent protocols, but provide

added value for a call between two devices of the same type. In this case, the agent interworking protocol preferably supports tunneling of the native protocol message. As used herein, tunneling refers to transferring the native protocol message from one protocol agent to another protocol agent without
5 converting to and from the agent interworking protocol. The agent receiving the native protocol message can inspect the message, and if the agent understands the message, process the message accordingly.

An example of when it might be desirable to tunnel a message relates to H.323. H.323 provides a sophisticated means of representing terminal
10 capabilities in sets. The agent interworking protocol, as described herein, might not include functionality for representing terminal capabilities in sets as defined in H.323, because the other protocols do not support such capability. Another capability that H.323 supports which can not be supported by other protocols is the exchange of H.245 indications between two H.323 devices.
15 Some of these indications have no equivalent mapping to other agent protocols. In these situations, it can be desirable to tunnel the H.323 messages from one agent to another agent.

Method of Tunneling Messages

According to an embodiment of the present invention, interworking
20 messages can be of three types:

- Agent interworking protocol messages – protocol-neutral messages understood by all protocol agents;
- Native protocol messages – protocol-specific messages, such as SIP, MGCP, and H.323 messages;

- Multipart messages - messages that contain multiple other messages, such as native protocol messages and AIP messages. All agents are preferably capable of extracting the AIP message and processing the message accordingly. If the multipart message contains a native protocol message, this message is preferably processed if supported.

Figures 9(a) and 9(b) are flow charts illustrating exemplary formulating and processing of interworking messages by a call server according to an embodiment of the present invention. The flow chart in Figure 9(a) illustrates exemplary steps that can be performed by a sending protocol agent in formulating an interworking message using procedures provided by an associated interworking agent. The flow chart in Figure 9(b) illustrates exemplary steps that can be performed by a receiving protocol agent using procedures provided by an associated interworking agent upon receiving an interworking message. Referring to Figure 9(a), in step **ST1**, the sending protocol agent receives a message from an external entity, such as an H.323 gateway. In step **ST2**, the sending protocol agent determines whether a mapping is available to the agent interworking protocol. In step **ST3**, if a mapping is available, the sending protocol agent formulates the corresponding AIP message using functions provided by the interworking agent associated with the sending protocol agent (hereinafter, "the first interworking agent") and transmits the message to the receiving protocol agent (step **ST4**). In step **ST2**, if the sending protocol agent determines that the mapping to the agent interworking protocol is not available, the sending protocol agent simply transmits the protocol message without modification to the receiving protocol agent (step **ST4**). In step **ST2**, if the sending protocol

agent determines that a mapping to AIP is partially available, the sending protocol agent can formulate a multiprotocol message including the AIP message and the native protocol message (step **ST5**). The sending protocol agent can then transmit the multiprotocol message to the receiving protocol agent (step **ST4**).

Referring to Figure 9(b), in step **ST6**, the receiving protocol agent receives the message from the sending protocol agent. In step **ST7**, receiving protocol agent determines the message type, i.e., whether the message is a protocol specific message, an agent interworking protocol message, or a multipart message, using procedures provided by its associated interworking agent (hereinafter, "the second interworking agent"). In step **ST8**, if the receiving protocol agent determines that the message is an agent interworking protocol message, the receiving protocol agent processes the message (step **ST9**). In step **ST10**, the receiving protocol agent determines whether the message is a multipart message. If the message is a multipart message, the receiving protocol agent separates the multi-protocol message into its component messages (step **ST11**). After the receiving protocol agent separates the message, the receiving protocol agent reads the protocol specific portion of the AIP message (step **ST12**). In step **ST13**, the receiving protocol agent determines whether the protocol in the protocol specific portion is supported. If the protocol is not supported, the receiving protocol agent discards the message (step **ST14**). If the protocol is supported, the receiving protocol agent processes the message (step **ST15**). In step **ST16**, the receiving protocol agent processes the AIP portion of the message.

Referring to step **ST17**, if the receiving protocol agent determines that the message is a protocol specific message, the receiving protocol agent determines whether the protocol of the message is supported (step **ST18**). If the protocol is supported, the receiving protocol agent processes the message (step **ST19**). If the protocol is not supported, the receiving protocol agent discards the message (step **ST20**).

Transport Mechanism for Agent Interworking Messages

Interworking messages can be sent between protocol agents using any packet based protocol, for example, TCP, UDP, etc. In a preferred embodiment of the invention, interworking messages are transmitted between interworking agents using TCP over IP. As is known in the art, an IP message includes a header portion and a data portion. A TCP message is encapsulated in the data portion of the IP message. The TCP message also includes a header portion and a data portion. Interworking messages are encapsulated in the data portion of the TCP message. Interworking messages also include a header portion and a data portion. The header portion indicates the message type, i.e., AIP, protocol-specific, or multipart.

Figure 10 illustrates the relationships between IP messages, TCP messages, and interworking messages. In Figure 10, IP message **1000** includes a header portion **1002** and a data portion **1004**. TCP message **1006** is encapsulated in data portion **1004** of IP message **1000**. TCP message **1006** includes a header portion **1008** and a data portion **1010**. Interworking message **1012** is encapsulated in data portion **1010** of TCP message **1006**. Interworking message **1012** includes a header portion **1014** for indicating the message type and a data portion **1016** containing the

- actual message. If the header portion **1014** indicates that the interworking message is a multipart message, data portion **1016** of interworking message **1012** includes a first field **1018** indicating the number of messages present in the multipart message. After the first field, the multipart message can
- 5 include one or more interworking messages **1012A** to **1012N**.

DTMF Digit Handling

- Another extension of the base protocol provided by the agent interworking protocol is dual tone multifrequency (DTMF) digit handling. Numerous studies have concluded that encoding and transporting DTMF
- 10 digits within the media stream is not suitable for supporting networked services, such as credit card validation, automated services, and voice mail, which require DTMF digit recognition. Some of these services require recognition not only of the tone being transmitted but also of the duration of the tone. Algorithms for encoding voice and data can distort the tone and/or
- 15 change the duration of the tone sought to be transmitted. As a result, the receiving application might not be able to correctly interpret the tone.

- Currently, a fully standardized approach for handling the transport of DTMF digits after call establishment is not defined. The approach that is currently in the most favor is to encode DTMF digits as a special real time
- 20 protocol (RTP) payload type that is exchanged between devices participating in the media stream. If this approach is standardized, various digital signal processor (DSP) manufacturers must comply with the standard before interworking will be accomplished. Because this involves a hardware change, much time can elapse before this occurs.

As a current solution to the problem, some of the agent protocols have implemented out-of-band techniques for handling DTMF digits. The agent interworking protocol according to embodiments of the present invention preferably provides a mapping to and from the out-of-band DTMF digit handling techniques of supported protocols. In order to provide a method for communicating DTMF information between protocol agents, the agent interworking protocol defines a data structure referred to herein as the digit information parameter. Figure 11 illustrates an exemplary digit information parameter data structure. In the illustrated embodiment, the digit information parameter data structure includes a digit field **1100** and a duration field **1102**. Digit field **1100** is capable of storing a digit value indicative of the DTMF digit being transmitted. For example, the digit field can contain a numerical value that indicates one of the keys on a telephone handset. Duration field **1102** stores a duration value for indicating the duration of the tone represented by the digit in the digit field. Specific examples of when the digit information parameter is exchanged will be explained below with reference to the call flow diagrams.

Interworking Examples

A. H.323 Fast Start to MGCP

Figure 12 is a call flow diagram illustrating exemplary call signaling performed by H.323 and MGCP agents including interworking agent capabilities according to an embodiment of the present invention. In Figure 12, H.323 endpoint **1200** is seeking to establish a call with an MGCP endpoint through MGCP gateway **1202**. MGCP gateway **1202** performs both signaling gateway and media gateway functions. H.323 agent **1204**

includes interworking agent functionality and implements an originating call model. MGCP agent **1206** includes interworking agent functionality and implements a terminating call model.

- In line 1 of the call flow diagram, H.323 endpoint **1200** sends a
- 5 SETUP message to H.323 agent **1204**. The SETUP message includes fast start parameters that specify suggested media options for the initial media stream. In line 2 of the call flow diagram H.323 agent **1204** sends an agent interworking protocol initial address message (IAM) to MGCP agent **1206**. The AIP IAM message contains the media capabilities definition mapped
- 10 from the fast start parameters extracted from the SETUP message. In line 3 of the call flow diagram, MGCP agent **1206** sends an MGCP create connection (CRCX) message to MGCP gateway **1202**. The CRCX message contains local connection options that are mapped from the AIP media capabilities information extracted from the IAM message into MGCP format.
- 15 In line 4 of the call flow diagram, MGCP gateway **1202** sends an OK message to MGCP agent **1206**. The OK message includes a media capability selected by MGCP gateway **1202** from the media capabilities specified in the CRCX message. The media description for the selected capability is returned in the SDP portion of the OK message.
- 20 In line 5 of the call flow diagram, MGCP agent **1206** sends an AIP call progress (CGP) message to H.323 agent **1204**. An AIP CPG message is used to signal events other than release and answer between protocol agents implementing different call halves. In the illustrated example, the CPG message includes a mapping of the SDP portion of the OK message
- 25 into AIP format. In addition, any other media capabilities which the MGCP

agent is capable of supporting can be included in the media description. In line 6 of the call flow diagram, H.323 agent **1204** transmits an ALERTING message to H.323 endpoint **1200**. H.323 agent **1204** maps the media description from the AIP CPG message into fast start parameters and

5 includes the fast start parameters in the ALERTING message. Any additional capabilities that were received by the H.323 agent are stored for later usage.

In line 7 of the call flow diagram, when the MGCP end user answers the call, signaling gateway **1202** sends a NOTIFY message to MGCP agent

10 **1206**. The NOTIFY message alerts MGCP agent **1206** of the off-hook event. In line 8 of the call flow diagram, in response to the NOTIFY message, MGCP agent **1206** transmits an AIP answer message (ANM) to H.323 agent **1204**.

In line 9 of the call flow diagram, in response to the answer message,

15 H.323 agent **1204** transmits a CONNECT message to H.323 endpoint **1200**. In lines 10 and 11 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1204** exchange master/slave and master/slave acknowledge messages. These messages are sent according to H.245 master/slave determination. This determination is made to resolve conflicts in media

20 formats. H.323 agent **1204** handles the exchange and does not map the exchange to the agent interworking protocol.

In line 12 of the call flow diagram, H.323 endpoint **1200** transmits an H.245 terminal capabilities set (TCS) message to H.323 agent **1204** to communicate the media capabilities of endpoint **1200** to H.323 agent **1204**.

25 In line 13, H.323 agent **1204** acknowledges the TCS message. In line 14 of

the call flow diagram, H.323 agent **1204** transmits a multipart message to MGCP agent **1206**. The multipart message includes the capabilities of the H.323 device mapped into AIP format. The capabilities are sent to MGCP agent **1206** in the AIP CPG message. Optionally, the H.245 representation
5 of the TCS can be sent as well. In this case, a multipart message is sent between call halves. The multipart message includes both the AIP CPG message and the H.245 TCS message. Because MGCP agent **1206** might not support H.245 TCS, MGCP agent **1206** might, i.e., if H.245 TCS is not supported, discard the TCS portion of the multipart message and process
10 only the AIP portion.

In lines 15 and 16 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1204** exchange TCS and TCS ACK messages. In this exchange, the capabilities of the other end, i.e., of MGCP gateway **1202**, which were received and stored upon receipt of the CPG message in line 5
15 of the call flow diagram, are sent to H.323 endpoint **1200** as an H.245 terminal capability set.

H.323 Non-Fast Start to MGCP

While Figure 12 illustrated H.323 to MGCP interworking for H.323 fast start procedures, Figure 13 illustrates H.323 to MGCP interworking without
20 fast start procedures. In other words, in Figure 13, the H.323 media capabilities are not exchanged until after call establishment. The entities involved in communications in Figure 13 are the same as those illustrated in Figure 12. Thus, a description of these entities is not repeated herein.

Referring to Figure 13, in line 1 of the call flow diagram, H.323
25 endpoint **1200** sends a SETUP message to H.323 agent **1204**. The SETUP

message does not include fast start parameters. In line 2 of the call flow diagram, H.323 agent **1204** transmits an AIP IAM message to MGCP agent **1206**. The IAM message contains no media description. In other words, the connection information parameter is either not included or set to a null value.

- 5 In line 3 of the call flow diagram, MGCP agent **1206** transmits a CRCX message to MGCP gateway **1202**. The CRCX message can optionally contain a default set of media capabilities that do not reflect capabilities supported by the H.323 endpoint. A CRCX message example is as follows:

CRCX:

10

R: HD

L: Default media capabilities

M: Inactive (or receive only)

- In the CRCX message example, the hd value in the R field instructs gateway **1202** to go off-hook. The value in the L field specifies local connection options, which indicate to gateway **1202** the media capabilities of H.323 endpoint **1200**. In response to the CRCX message, in line 4 of the call flow diagram, MGCP gateway **1202** transmits an OK message to MGCP agent **1206**. The OK message includes an SDP portion with the media description for the connection. An exemplary media description is as follows:

20

v=0

c=IP address

m=media description

- In the exemplary media description set forth above, the IP address in the c= parameter is the IP address on MGCP gateway **1202** for receiving the media stream. The media description specified in the m= parameter includes the
- 25

type of media that the media gateway is capable of receiving, e.g., voice, data, or video.

In line 5 of the call flow diagram, MGCP agent **1206** transmits an AIP call progress (CPG) message to H.323 agent **1204**. The AIP CPG message includes the connection information parameter data structure in which the media description from the SDP portion of the AIP message is mapped into AIP format. The media description is stored by H.323 agent **1204**, but is not transmitted to H.323 endpoint **1200** as a fast start parameter.

In line 6 of the call flow diagram, H.323 agent **1204** transmits an ALERTING message to H.323 endpoint **1200**. The ALERTING message notifies H.323 endpoint **1200** that the MGCP end user is being alerted. When the MGCP end user answers the call, in line 7 of the call flow diagram, MGCP gateway **1202** transmits a NOTIFY message to MGCP agent **1206**. In line 8 of the call flow diagram, MGCP agent **1206** transmits an AIP answer message (ANM) to H.323 agent **1204**. In line 9 of the call flow diagram, H.323 agent **1204** transmits a CONNECT message to H.323 endpoint **1200**. In lines 10 and 11 of the call flow diagram, the H.245 master/slave determination takes place. H.323 agent **1204** handles the exchange and does not map the exchange to the agent interworking protocol.

In lines 12 and 13 of the call flow diagram H.323 endpoint **1200** and H.323 agent **1204** exchange H.245 TCS and H.245 TCS ACK messages. This exchange communicates the media capabilities of H.323 endpoint **1200** to H.323 agent **1204**. In line 14 of the call flow diagram, H.323 agent **1204** transmits a multipart message to MGCP agent **1206**. H.323 agent **1204** maps the capabilities of H.323 endpoint **1200** into AIP format and includes

these capabilities in an AIP CPG message. Optionally, the H.245 representation of the TCS can be sent as well. In this example, a multipart message is sent that includes both the AIP CPG message and the H.245 TCS message. Since MGCP agent **1206** can not support H.245 TCS, MGCP agent **1206** can only process the AIP portion of the multipart message.

In lines 15 and 16 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1204** exchange TCS and TCS ACK messages. In this exchange, the capabilities of MGCP gateway **1202**, which were received and stored upon receipt of the AIP CPG message in line 5 of the call flow diagram, are sent to H.323 endpoint **1200** as an H.245 terminal capability set. In lines 17 - 20 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1204** exchange H.245 OPEN LOGICAL CHANNEL and H.245 OPEN LOGICAL CHANNEL ACKNOWLEDGE messages. In this exchange, H.323 agent **1204** two unidirectional media streams between the end users. H.323 endpoint **1200** returns its RTP port for each media stream in the acknowledge messages.

In line 21 of the call flow diagram, H.323 agent **1204** transmits an AIP CPG message to MGCP agent **1206**. CPG message contains an updated media description to reflect the RTP address of H.323 endpoint **1200** and the mode change to send receive. In line 22 of the call flow diagram, MGCP agent **1206** transmits a modify connection message to MGCP gateway **1202**. This updates the media description at MGCP gateway **1202** and a full duplex media path between end users is complete.

H.323 – NAQ.931 Call Hold Scenario

Figure 14 illustrates interworking between an H.323 endpoint and an NAQ.931 device for a call hold scenario. In Figure 14, it is assumed that a bi-directional media stream has been established between H.323 endpoint

5 **1200** and NAQ.931 device **1400**. H.323 endpoint **1200** can be an IP terminal, as previously described with respect to Figure 12. NAQ.931 device **1400** can comprise an IP terminal. H.323 agent **1402** includes interworking agent capabilities as well as H.323 gatekeeper capabilities. Similarly, NAQ.931 agent **1404** includes interworking agent capabilities as well as

10 NAQ.931 agent capabilities.

In line 1 of the call flow diagram, NAQ.931 device **1400** transmits a HOLD message to NAQ.931 agent **1404**. In line 2 of the call flow diagram, in response to the HOLD message, NAQ.931 agent **1404** transmits an AIP CPG message to H.323 agent **1402**. The CPG message includes the

15 connection information parameter data structure. The channel operation field in the data structure is set to mode change, and the mode field in the data structure is set to inactive. In line 3 of the call flow diagram, H.323 agent **1402** transmits a TCS = 0 message to H.323 endpoint **1200**. In line 4 of the call flow diagram, H.323 agent **1402** transmits a CLOSE LOGICAL

20 CHANNEL message to H.323 endpoint **1200**. The CLOSE LOGICAL CHANNEL message closes one of the two channels between H.323 endpoint **1200** and NAQ.931 device **1400**. In line 5 of the call flow diagram, NAQ.931 agent **1404** transmits a FACILITY message to NAQ.931 device **1400**. The FACILITY message indicates that inactive mode has been

25 entered. In line 6 of the call flow diagram, H.323 endpoint **1200** transmits a

CLOSE LOGICAL CHANNEL ACKNOWLEDGE message to H.323 agent **1402** acknowledging the closing of logical channel 1.

In lines 7 and 8 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange H.245 CLOSE LOGICAL CHANNEL and
5 CLOSE LOGICAL CHANNEL ACKNOWLEDGE messages for logical channel 2. Once logical channel 2 is closed, in line 9 of the call flow diagram H.323 agent **1402** transmits an AIP CPG message to NAQ.931 agent **1404**. The AIP CPG message includes the connection information parameter. The change operation field in the connection information parameter data
10 structure is set to mode change, and the mode is set to inactive.

H.323 – NAQ.931 Call Retrieve Scenario

Figure 15 illustrates H.323 to NAQ.931 interworking for a call retrieve scenario. The entities illustrated in Figure 15 are the same as those illustrated in Figure 14. Hence, a description thereof is not repeated herein.
15 In Figure 15, it is assumed that a call between H.323 endpoint **1200** and NAQ.931 device **1400** has been put on hold. Thus, the signaling that must occur between H.323 endpoint **1200** and NAQ.931 device **1400** to retrieve the call includes reopening the logical channels between H.323 endpoint **1200** and NAQ.931 device **1400**.

20 In line 1 of the call flow diagram illustrated in Figure 15, NAQ.931 device **1400** transmits a RETRIEVE message to NAQ.931 agent **1404**. In line 2 of the call flow diagram, NAQ.931 agent **1404** transmits an AIP CPG message to H.323 agent **1402**. The CPG message includes the connection information parameter data structure with the change operation field set to
25 mode change and the mode set to send/receive. In lines 3 and 4 of the call

flow diagram, the H.245 master/slave determination occurs between H.323 endpoint **1200** and H.323 agent **1402**. H.323 endpoint **1200** and H.323 agent **1402** must revert to a TCS exchange in order to reestablish the media streams. Accordingly, in lines 5 and 6 of the call flow diagram H.323
5 endpoint **1200** and H.323 agent **1402** exchange TCS and TCS ACK messages.

In line 7 of the call flow diagram H.323 endpoint **1200** transmits an H.245 OPEN LOGICAL CHANNEL to H.323 agent **1402**. In line 8 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to
10 NAQ.931 agent **1404**. The CPG message includes the connection information parameter data structure. The channel operation field and the data structure is set to mode change and the mode is set to send only. This reestablishes one of the media streams between H.323 endpoint **1200** and NAQ.931 device **1400**. In line 9 of the call flow diagram, NAQ.931 agent
15 **1404** transmits a FACILITY message to NAQ.931 device **1400**. The FACILITY message includes a mode parameter that sets the channel to be receive only.

In line 10 of the call flow diagram H.323 agent **1402** transmits an OPEN LOGICAL CHANNEL ACKNOWLEDGE message to H.323 endpoint
20 **1200** acknowledging the opening of logical channel 1. In line 11 of the call flow diagram, H.323 agent **1402** transmits an H.245 OPEN LOGICAL CHANNEL message to H.323 endpoint **1200** to open logical channel 2. In line 12 of the call flow diagram, H.323 endpoint **1200** transmits an H.245 OPEN LOGICAL CHANNEL ACKNOWLEDGE message to H.323 agent
25 **1402**. In line 13 of the call flow diagram, H.323 agent **1402** transmits an AIP

CPG message to NAQ.931 agent **1404**. The CPG message includes the connection information parameter data structure. The channel operation field in the data structure is set to mode change and the mode field is set to send/receive. In line 14 of the call flow diagram, NAQ.931 agent **1404**
5 transmits a FACILITY message to NAQ.931 device **1400**. The FACILITY message includes a mode field that sets the mode to be send/receive. Once this message is received, both logical channels are open between H.323 endpoint **1200** and NAQ.931 device **1400**.

H.323 – MGCP Hold Scenario

10 Figure 16 illustrates interworking for an H.323 – MGCP hold scenario. In Figure 16, it is assumed that a call has been established between H.323 endpoint **1200** and MGCP device **1600**. MGCP device **1600** is assumed to support an event package for call hold and retrieve events. H.323 device **1200** is the same as H.323 device **1200** described with respect to Figure 12,
15 and hence a description thereof is not repeated herein. MGCP device **1600** can be an MGCP device, such as a media gateway. MGCP agent **1602** includes interworking agent functionality as well as MGCP media gateway controller functionality. H.323 agent **1402** is the same as H.323 agent **1402** described with respect to Figure 14, and hence a description thereof is not
20 repeated herein.

In line 1 of the call flow diagram, MGCP device **1600** transmits a NOTIFY message to MGCP agent **1602**. The NOTIFY message includes an event that informs MGCP agent **1602** that the end user connected to MGCP device **1600** has placed the call on hold. In line 2 of the call flow diagram,
25 MGCP agent **1602** transmits an AIP CPG message to H.323 agent **1402**.

The AIP CPG message includes the connection information parameter. The channel operation field in the connection information parameter data structure is set to mode change and the mode field is set to inactive. In line 3 of the call flow diagram, H.323 agent **1402** transmits a TCS = 0 message to H.323 endpoint **1200**.

In lines 4 and 5 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange CLOSE LOGICAL CHANNEL messages to close the logical channel between H.323 endpoint **1200** and MGCP device **1600**. In line 6 of the call flow diagram, MGCP agent **1602** transmits a MODIFY connection (MDCX) message to MGCP device **1600** indicating that the mode has been set to inactive. In lines 7 and 8 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange the messaging required to close logical channel 2. H.323 agent **1402** interprets the inactive mode as a hold and applies H.323 third party calls and rerouting procedures to implement the hold actions. These procedures result in the closing of both unidirectional media streams between H.323 endpoint **1200** and MGCP device **1600**. In line 9 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to MGCP agent **1602**. The CPG message includes the connection information parameter data structure. The channel operation field in the connection information data structure is set to mode change, and the mode field is set to inactive.

H.323 – MGCP Retrieve Scenario

Figure 17 illustrates an H.323 – MGCP retrieve scenario. The entities illustrated in Figure 17 are the same as those illustrated in Figure 16, and hence a description thereof is not repeated herein. In Figure 17, it is

assumed that a call between H.323 endpoint **1200** and MGCP device **1600** has been placed on hold.

In line 1 of the call flow diagram, MGCP device **1600** transmits a NOTIFY message to MGCP agent **1602**. The NOTIFY message contains an event that indicates to MGCP agent **1602** that the end user connected to MGCP device **1600** wishes to retrieve the call. In line 2 of the call flow diagram, MGCP agent **1602** transmits an AIP CPG message to H.323 agent **1402**. The AIP CPG message includes the connection information parameter data structure. The channel operation field in the data structure is set to mode change, and the mode field is set to send/receive.

In lines 3 and 4 of the call flow diagram, H.323 agent **1402** and H.323 endpoint **1200** make a master/slave determination. The H.323 devices must revert to a TCS exchange in order to reestablish the media streams. Accordingly, in lines 5 and 6 of the call flow diagram, H.323 agent **1402** and H.323 endpoint **1200** exchange terminal capabilities.

In line 7 of the call flow diagram, H.323 endpoint **1200** transmits an H.245 open logical channel message to H.323 agent **1402** to open one of the logical channels between H.323 endpoint **1200** and MGCP device **1600**. In line 8 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to MGCP agent **1602**. The AIP CPG message includes the connection information parameter data structure. The change operation field in the data structure is set to mode change, and the mode field is set to send only. In line 9 of the call flow diagram, MGCP agent **1602** transmits a modify connection message to MGCP device **1600**. The modify connection message includes a mode field setting the mode to receive only. In line 10

of the call flow diagram H.323 agent **1402** acknowledges the H.245 open logical channel messages transmitted in line 7 of the call flow diagram.

In lines 11 and 12 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange messaging for opening the other logical channel between H.323 endpoint and MGCP device **1600**. In line 13 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to MGCP agent **1602**. The CPG message includes the connection information parameter data structure. The channel operation field in the data structure is set to mode change, and the mode field is set to send/receive. In line 14 of the call flow diagram, MGCP agent **1602** transmits a modify connection message to MGCP device **1600**. The modify connection message instructs the device to change the mode to send/receive. At this point, both media streams between H.323 endpoint **1200** and MGCP device **1600** are established.

15 H.323 to MGCP Primary Rate Interface (PRI)
 Common Channel Signaling (CCS)

Figure 18 illustrates exemplary call signaling for H.323 to MGCP PRI (CCS). In Figure 18, signaling gateway **1800** relays call control signaling between a circuit-switched network and a packet-switched network. For example, signaling gateway **1800** may be connected to a PSTN end office on one side and to an IP network on the other side. In the illustrated embodiment, signaling gateway **1800** is configured to forward Q.931 call signaling messages from the PSTN network to a packet network and vice-versa. On the circuit-switched side, SG **1800** can be configured to send and receive Q.931 over Q.921 call signaling messages. On the packet-switched

side, signaling gateway **1800** can be configured to send and receive Q.931 over ISDN User Adaptation over TCP/IP messages.

Media gateway **1802** converts between packets and circuits to communicate the media stream to and from a PSTN end user device. On the circuit-switched side, media gateway **1802** can send and receive the media stream using pulse code modulation (PCM) voice. On the packet-switched side, media gateway **1802** can send and receive the media stream using RTP over UDP/IP. In the illustrated embodiment, media gateway **1802** is controlled using MGCP.

CCS agent **1804** exchanges call control information with signaling gateway **1800** and media control information with media gateway **1802**. In the illustrated embodiment, CCS **1804** communicates with signaling gateway **1800** using Q.931 call signaling over IUA over TCP/IP and with media gateway **1802** using MGCP. CCS agent **1804** also communicates with H.323 agent **1806** using the agent interworking protocol, as described above. It is understood that CCS agent **1804** and H.323 agent **1806** can be part of a call server. H.323 agent **1806** and H.323 gateway **1808** exchange call signaling information according to ITU Recommendation H.225.

In line 1 of the call flow diagram, signaling gateway **1800** transmits a SETUP message to CCS agent **1804**. The SETUP message includes information, such as the dialed digits for creating a call with the called party. In line 2 of the call flow diagram CCS agent **1804** transmits a CALL PROCEEDING message to signaling gateway **1800** to indicate that CCS agent **1804** is attempting to establish a call with the called party. In line 3 of the call flow diagram, CCS agent **1804** sends an MGCP CREATE

CONNECTION message to media gateway **1802**. In response to the
CREATE CONNECTION message, media gateway **1802** transmits an
ACKNOWLEDGE message including an SDP portion that specifies the
supported media capabilities of media gateway **1802**. In line 5 of the call
5 flow diagram, CCS agent **1804** transmits an AIP IAM message to H.323
agent **1806**. The AIP IAM message includes the connection information
parameter that specifies the supported media capabilities of media gateway
1802. In line 6 of the call flow diagram, H.323 agent **1806** transmits a
SETUP message specifying the media capabilities of media gateway **1802** to
10 H.323 to H.323 gateway **1808**. In line 7 of the call flow diagram, H.323
gateway agent **1808** transmits an ALERT message to H.323 agent **1806**
indicating that the called part is being alerted of the incoming call. The
ALERT message includes the supported media capabilities of H.323
gateway **1808**. In line 8 of the call flow diagram, H.323 agent **1806** sends an
15 AIP CALL PROGRESS message including the connection information
parameter specifying the media description of H.323 gateway **1808**. In line 9
of the call flow diagram, CCS agent **1804** transmits an ALERT message to
signaling gateway **1800** indicating that the called party is being alerted.

In line 10 of the call flow diagram, CCS agent **1804** transmits an
20 MGCP MODIFY CONNECTION message specifying the mode of the
connection as receive only and including the media description of H.323
gateway **1808**. In line 11 of the call flow diagram, media gateway **1802**
acknowledges the MODIFY CONNECTION message.

In line 12 of the call flow diagram, when the called party answers the
25 call, H.323 gateway **1808** transmits a CONNECT message to H.323 agent

1806. In line 13 of the call flow diagram, in response to receiving the CONNECT message, H.323 agent 1806 transmits an AIP ANSWER message to CCS agent 1804. In line 14 of the call flow diagram, CCS agent 1804 transmits a CONNECT message to signaling gateway 1800 indicating
5 that the call has been answered. In line 15 of the call flow diagram, CCS agent 1804 transmits a MODIFY CONNECTION message to media gateway 1802 opening the connection as send/receive. In line 16 of the call flow diagram, media gateway 1802 acknowledges the MODIFY CONNECTION message. At this point, a bi-directional media stream communication is
10 established between the called and calling parties. Thus, the call flow diagram illustrated in Figure 18 embodies the true MGCP reference architecture whereby the SG and MG are separate entities.

MGCP-H.323 Call Setup and Exchange of DTMF Digits

15 Figure 19 illustrates call signaling and exchange of DTMF digits between an MGCP gateway and an H.323 gateway. The entities illustrated in Figure 19 are the same as those illustrated in Figure 16. Hence, a description thereof is not repeated herein.

In Figure 19 it is assumed that a connection has already been
20 established between H.323 endpoint 1200 and MGCP device 1600. Therefore, call setup and teardown messages are not shown.

In line 1 of the call flow diagram, H.323 endpoint 1200 transmits a user input indication message to H.323 agent 1402 that includes the DTMF digit * encoded in the message. In line 2 of the call flow diagram, H.323
25 agent 1906 transmits an AIP_INFO message to MGCP agent 1602 that

indicates that information is being communicated to MGCP agent **1602**. The AIP_INFO message includes the digit information parameter that specifies the DTMF digit entered by the end user connected to H.323 gateway **1902**. In line 3 of the call flow diagram, MGCP agent **1602** transmits a MODIFY
5 CONNECTION message to MGCP device **1600**. The modify connection message includes a signal indicating the DTMF digit *. In line 4 of the call flow diagram, MGCP device **1600** acknowledges the modify connection message.

It will be understood that various details of the invention can be
10 changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation—the invention being defined by the claims.

CLAIMS

What is claimed is:

1. A call server comprising:

(a) a first protocol agent for communicating with a first internet
5 protocol (IP) telephony device according to a first IP telephony
protocol;

(b) a second protocol agent for communicating with a second IP
telephony device according to a second IP telephony protocol;
and

10 (c) an interworking agent for providing functions usable by the first
and second protocol agents to communicate with each other
according to a third protocol, the functions provided by the third
protocol being a superset of functions provided by the first and
second IP telephony protocols.

15 2. The call server of claim 1 wherein the interworking agent
comprises a first interworking agent associated with the first protocol
agent and a second interworking agent associated with the second
protocol agent.

20 3. The call server of claim 1 wherein the first protocol agent is a
media gateway control protocol (MGCP) agent, the first IP telephony
protocol is MGCP, the second protocol agent is ITU Recommendation
H.323 agent, and the second IP telephony protocol is H.323.

25

4. The call server of claim 1 wherein the first protocol agent is an International Telecommunications Union Recommendation H.323 agent, the first IP telephony protocol is H.323, the second protocol agent is a session initiation protocol (SIP) agent, and the second IP telephony is SIP.

5. The call server of claim 1 wherein the first protocol agent is an International Telecommunications Union Recommendation H.323 agent, the first IP telephony protocol is H.323, the second protocol agent is a Bellcore Q.931 agent, and the second IP telephony protocol is an extension of Bellcore Q.931.

6. The call server of claim 1 wherein the first protocol agent is a media gateway control protocol (MGCP) agent, the first IP telephony protocol is MGCP, the second protocol agent is a media gateway control protocol (MGCP) agent, and the second IP telephony protocol is MGCP.

7. The call server of claim 1 wherein the first protocol agent is an International Telecommunications Union Recommendation H.323 agent, the first IP telephony protocol is H.323, the second protocol agent is an H.323 agent, and the second IP telephony protocol is H.323.

8. The call server of claim 1 wherein the first protocol agent performs originating call half functions and the second protocol agent performs terminating call half functions.

5 9. The call server of claim 1 wherein the interworking agent is adapted to provide a connection information parameter data structure usable by the first and second protocol agents, for communicating media capabilities and media stream management information between the first and second protocol agents.

10 10. The call sever of claim 1 wherein the interworking agent is adapted to provide a digit information parameter usable by the first and second protocol agents for communicating dual tone multifrequency (DTMF) digits between the first and second protocol agents.

15 11. A method for interworking devices that communicate using different internet protocol (IP) telephony protocols, the method comprising:

20 (a) receiving, from a first telephony device, a first message formatted according to a first IP telephony protocol;

(b) in response to receiving the first message, generating a second message, formatted according to a second protocol, the second message including at least one of a media

capabilities description and media stream management information derived from the first message;

(c) transmitting the second message to a second protocol agent; and

5 (d) in response to receiving the second message, generating a third message formatted according to a third IP telephony protocol, the third message including at least one of the media capabilities description and media stream management information derived from the second message.

10

12. The method of claim 11 wherein receiving a first message includes receiving a message formatted according to the media gateway control protocol (MGCP) and generating a third message includes generating a message formatted according to ITU Recommendation H.323.

15

13. The method of claim 11 wherein receiving a first message includes receiving a message formatted according to the session initiation protocol (SIP) and generating a third message includes generating a message formatted according to ITU Recommendation H.323.

20

14. The method of claim 11 wherein receiving a first message includes receiving a first message formatted according to ITU

Recommendation H.323 and generating a third message includes generating a message formatted according to Bellcore Q.931.

5 15. The method of claim 11 wherein receiving a first message includes receiving a message formatted according to ITU Recommendation H.323 and generating a third message comprises generating a message formatted according to media gateway control protocol (MGCP).

10 16. The method of claim 15 wherein receiving a message formulated to ITU Recommendation H.323 includes receiving a message containing H.323 fast start parameters, wherein generating a second message includes mapping the H.323 fast start parameters to a media capabilities description in the second message, and
15 generating the third message includes mapping the media capabilities description to MGCP.

20 17. The method of claim 11 wherein receiving a first message includes receiving a HOLD message from the first telephony device, generating the second message includes generating a message including a connection information parameter having a mode change value for changing the mode of a media stream communication associated with the first telephony device, and wherein generating a third message includes generating a message for changing the mode

of the media stream communication to inactive according to the third IP telephony protocol.

5 18. The method of claim 11 wherein receiving a first message includes receiving a RETRIEVE message from the first telephony device, and generating the second message includes generating a message including a connection information parameter having a mode change value of active.

10 19. The method of claim 11 wherein receiving a first message includes receiving a message including at least one dual tone multifrequency (DTMF) digit value, generating the second message includes mapping the DTMF digit value to a digit information parameter value in the second protocol, and generating the third
15 message includes mapping the digit information parameter value to a DTMF digit value formatted according to the third IP telephony protocol.

20 20. The method of claim 11 comprising transmitting the third message to a second telephony device configured to communicate according to the third IP telephony protocol.

21. A method for tunneling messages between protocol agents, the method comprising:

- 5 (a) receiving, from a first telephony device, a first message formatted according to a first IP telephony protocol;
- (b) determining whether a parameter in the first message maps to a second protocol;
- (c) in response to determining that the parameter in the first message maps to the second protocol, formulating a second message formatted according to the second protocol; and
- 10 (d) in response to determining that the parameter in the first message does not map to the second protocol, transmitting the first message without alteration to a second protocol agent.

22. The method of claim 21 comprising in response to determining that the parameter in the first message partially maps to the second protocol, formulating a multiprotocol message, the multiprotocol message including a message formatted according to the first IP telephony protocol and a third message formatted to the second protocol.

15

23. The method of claim 22 comprising transmitting the multiprotocol message to a second protocol agent.

20

24. The method of claim 23 comprising in response to receiving the multiprotocol message, dividing the multiprotocol message into the second and third messages.

25

25. The method of claim 24 comprising after dividing the multiprotocol message, determining whether processing of the second message is supported by the second protocol agent, and in response to determining that the processing of the second message is supported, processing the second message.

26. The method of claim 25 comprising processing the third message.

27. A computer program product comprising computer-executable instructions embodied in a computer readable medium for performing steps comprising:

- (a) invoking a first protocol agent for communicating with a first internet protocol (IP) telephony device according to a first IP telephony protocol;
- (b) invoking a second protocol agent for communicating with a second IP telephony device according to a second IP telephony protocol;
- (c) mapping media capabilities information extracted from messages received from the first and second IP telephony devices formatted according to the first and second IP telephony protocols to a third protocol; and
- (e) transmitting messages containing the media capabilities information and formatted according to the third protocol between the first and second protocol agents.

28. The computer program product of claim 27 wherein invoking a first protocol agent includes invoking a first protocol agent for performing originating call functions and invoking a second protocol agent includes invoking a second protocol agent for performing terminating call functions.

29. The computer program product of claim 27 comprising, at the first protocol agent, mapping media stream information received from the second protocol agent to the first IP telephony protocol.

30. The computer program product of claim 27 comprising, at the second protocol agent, mapping media stream information received from the first protocol agent to the second IP telephony protocol.

31. The computer program product of claim 27 wherein the first IP telephony protocol is the media gateway control protocol and the second IP telephony protocol is ITU Recommendation H.323.

32. The computer program product of claim 27 wherein the first IP telephony protocol is ITU Recommendation H.323 and the second IP telephony protocol is Bellcore Q.931.

33. The computer program product of claim 27 wherein the first IP telephony protocol is the session initiation protocol and the second IP telephony protocol is IP Recommendation H.323.

Abstract of the Disclosure

A method and an apparatus for interworking between internet protocol (IP) telephony protocols includes a call server. The call server includes a first protocol agent for communicating with a first protocol device according to a first protocol. A second protocol agent communicates with a second protocol device according to a second protocol. An interworking agent provides functions usable by the first and second protocol agents to communicate with each other according to a third protocol. The third protocol is a superset of functions provided by the first and second protocols.

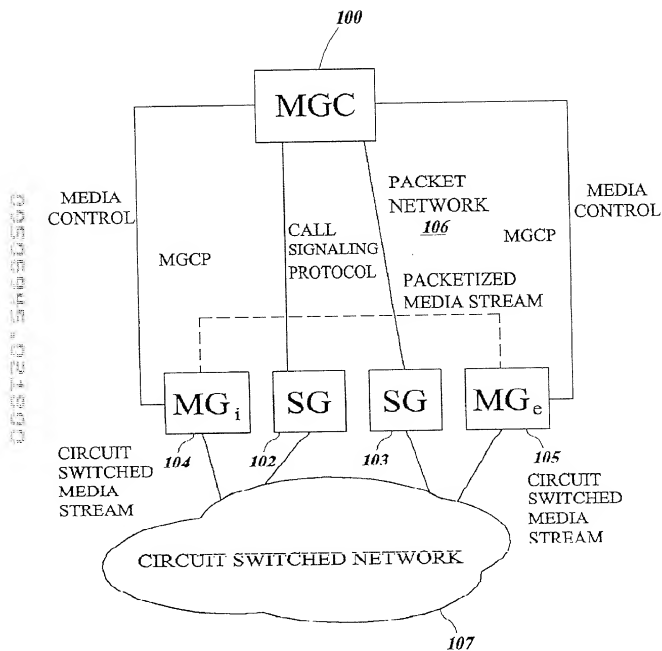


FIG. 1
(PRIOR ART)

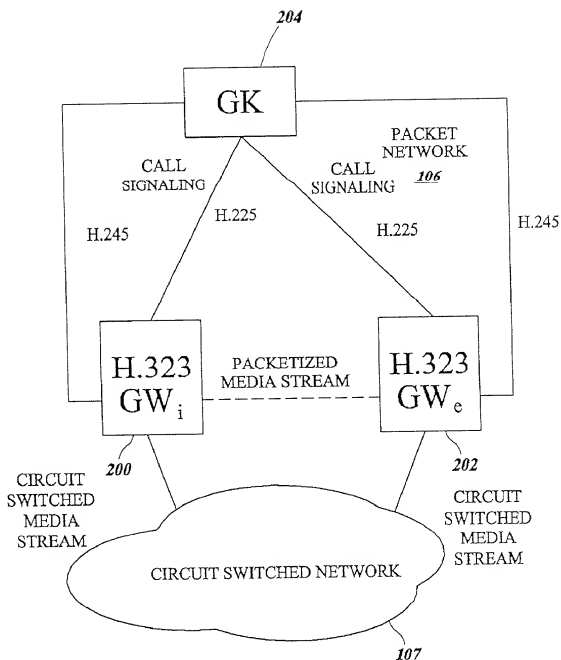


FIG. 2
(PRIOR ART)

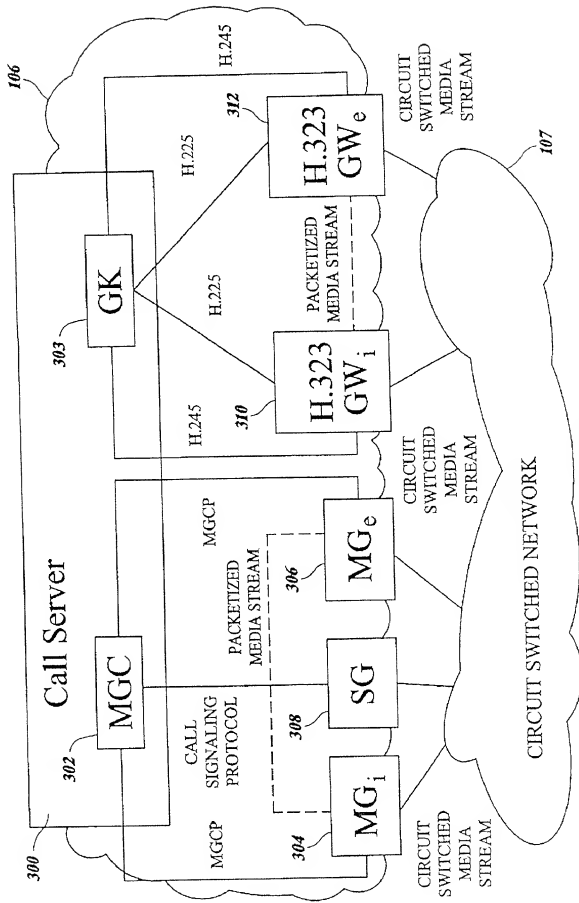
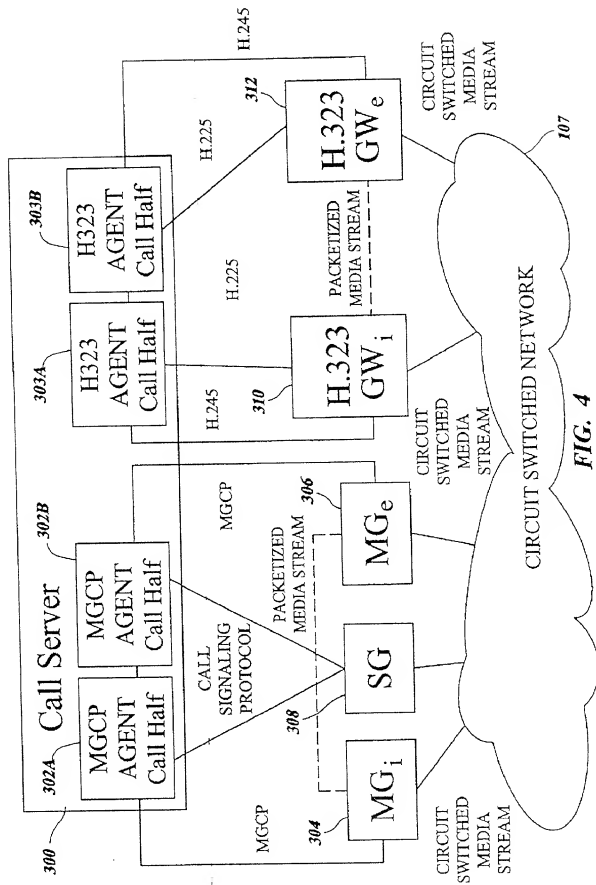


FIG. 3



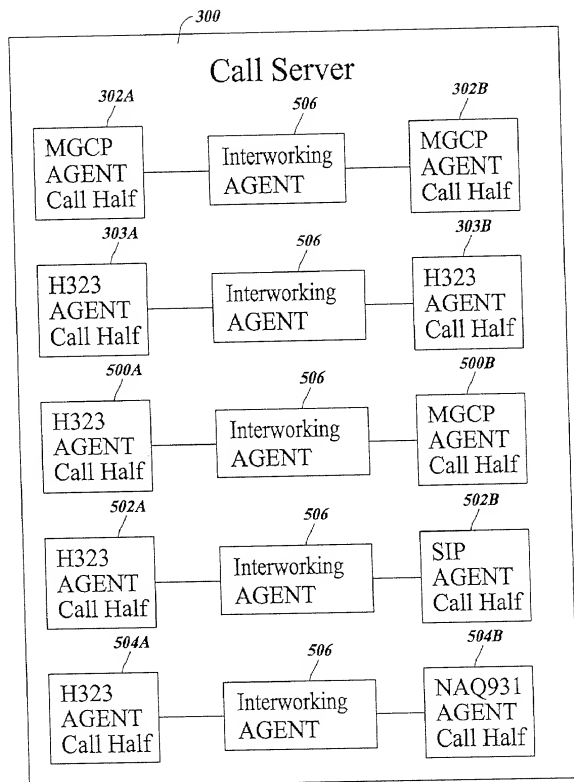


FIG. 5

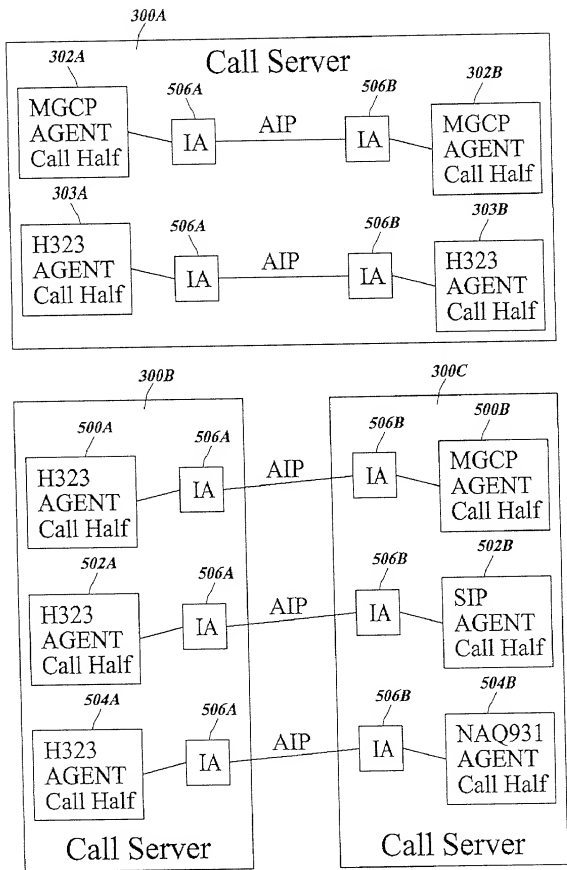


FIG. 6

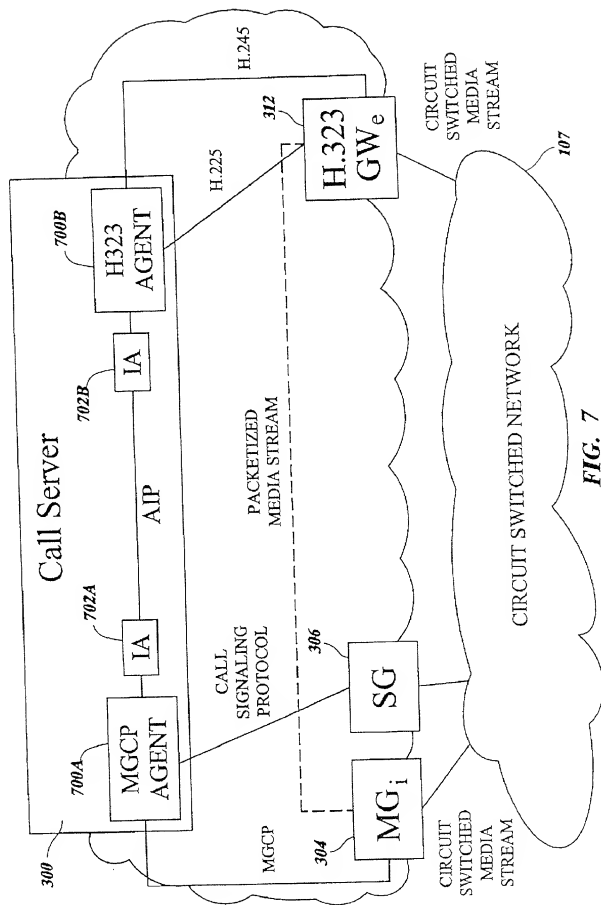


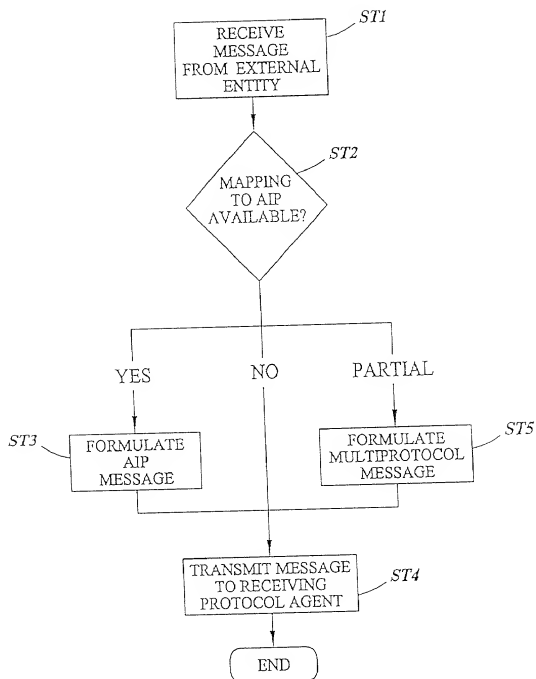
FIG. 7

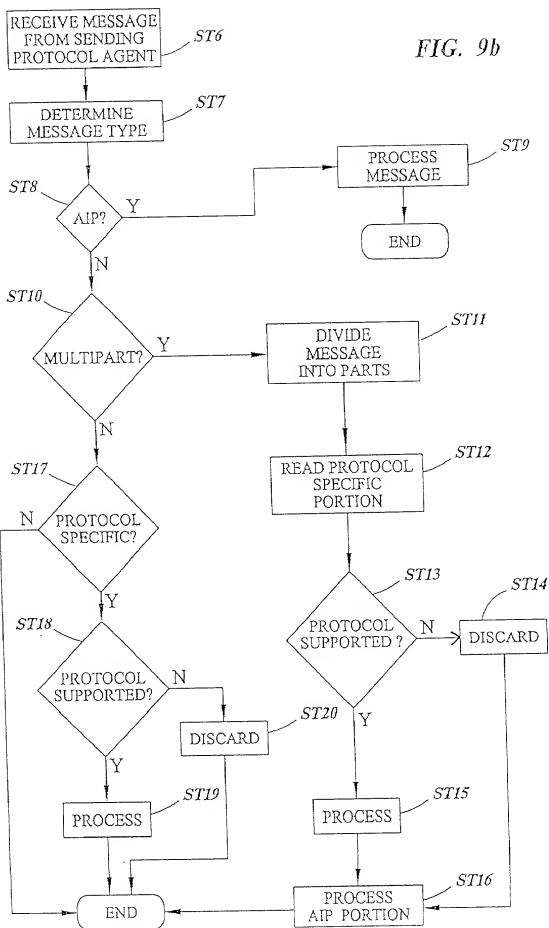
Connection Information Parameter

Field	Example Values
800 Media Type	Audio, Video, Data 802
804 Channel ID	12345 806
808 Channel Operation	No action, open, close, modify, mode change, redirect, direct, send capabilities 810
812 Current Media Description	G.711@2 frames/packet 814
816 Media Capabilities	G.711, G.729, RTP address, payload size, media specific information 818

FIG. 8

FIG. 9a





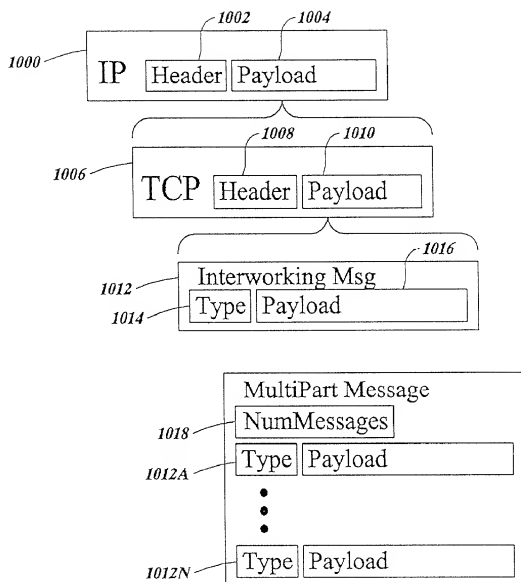


FIG. 10

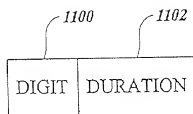


FIG. 11

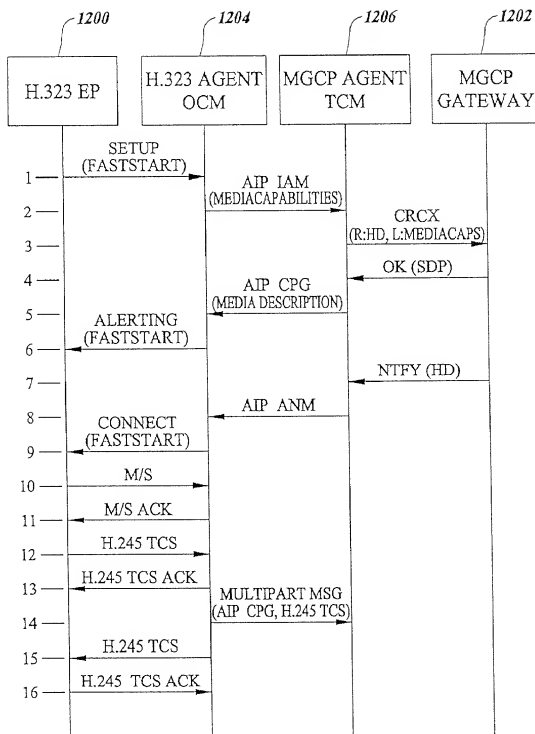


FIG. 12

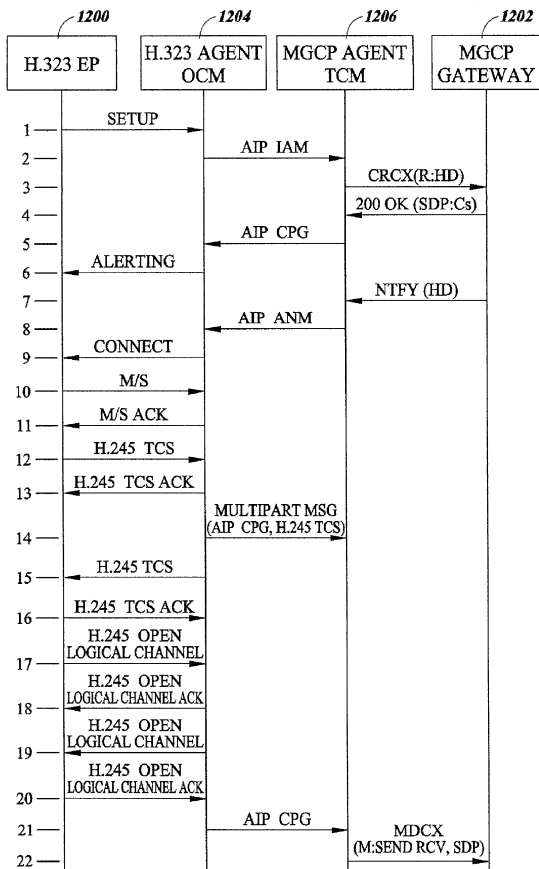


FIG. 13

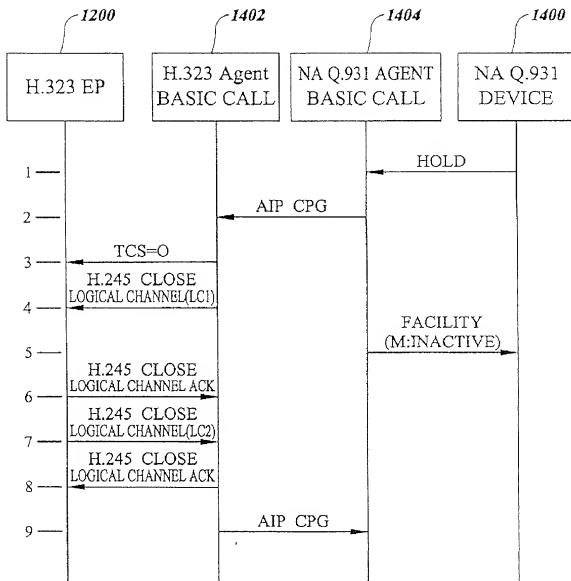


FIG. 14

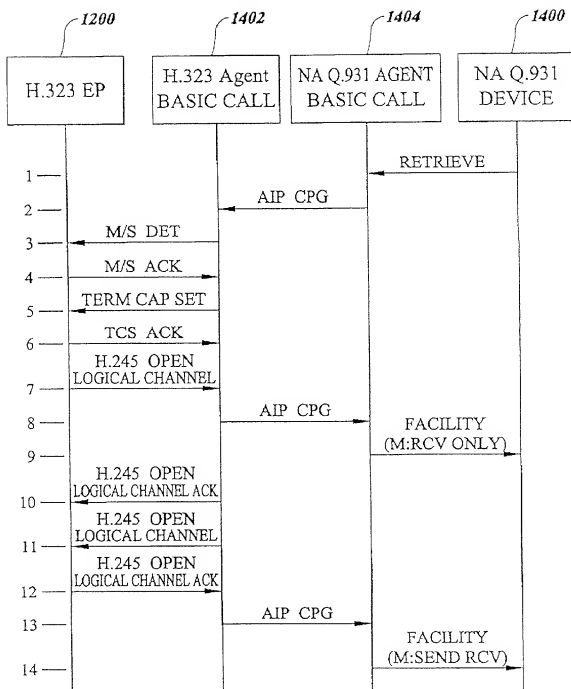


FIG. 15

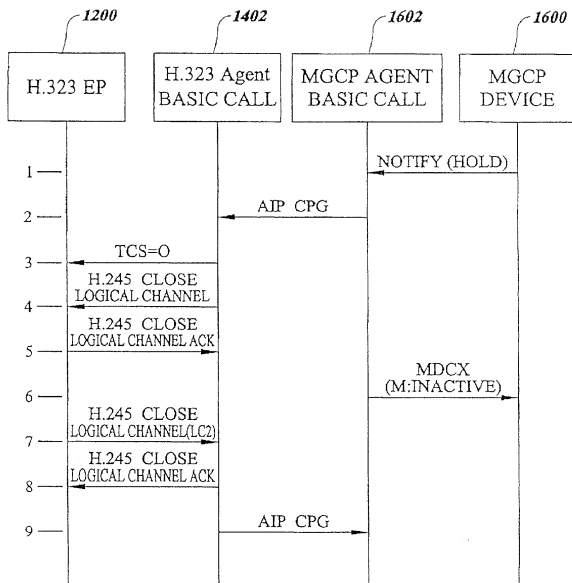


FIG. 16

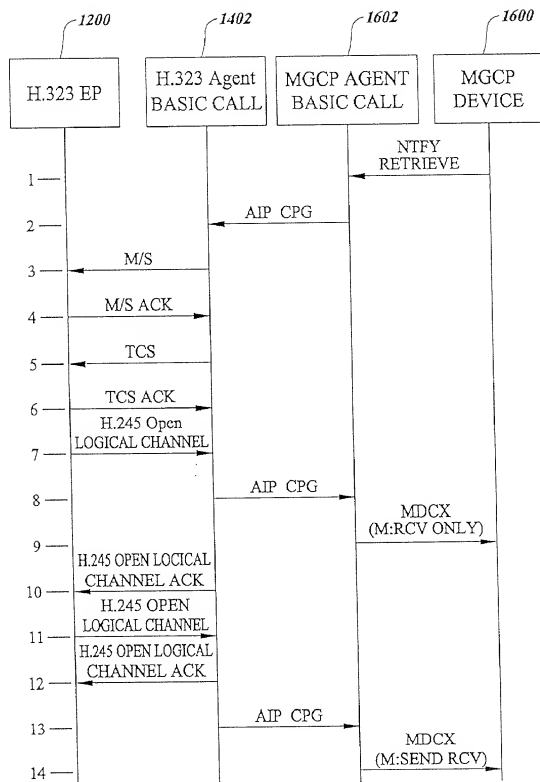


FIG. 17

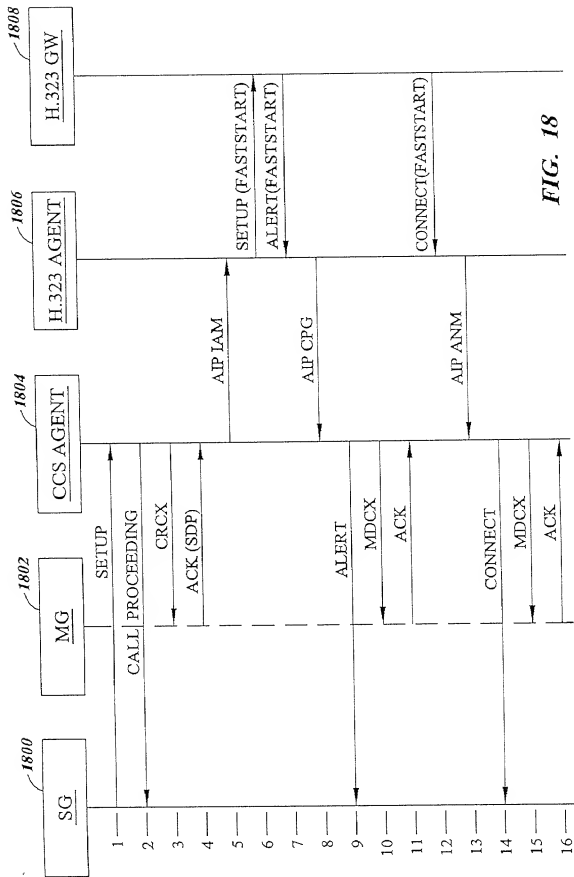


FIG. 18

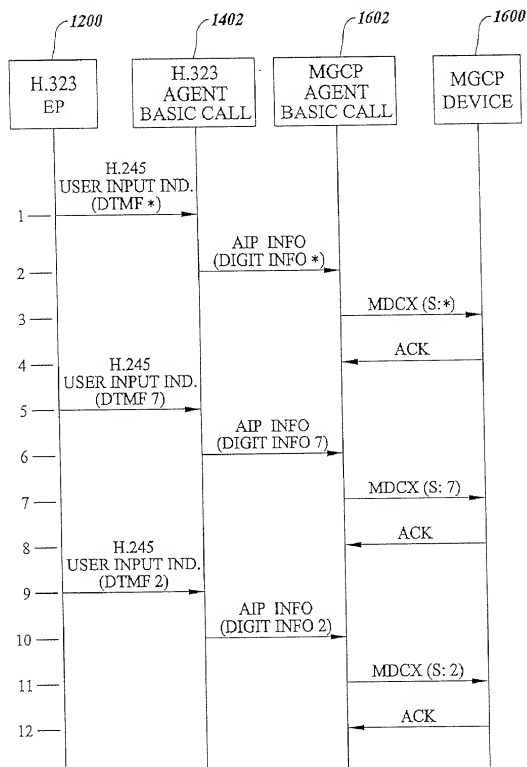


FIG. 19

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)		Attorney Docket Number	10619RNU02U:1273/19
		First Named Inventor	Ress et al.
		COMPLETE IF KNOWN	
		Application Number	Not Assigned
<input checked="" type="checkbox"/> Declaration Submitted with Initial Filing OR <input type="checkbox"/> Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)		Filing Date	Herewith
		Group Art Unit	Not Assigned
		Examiner Name	Not Assigned

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD AND APPARATUS FOR INTERWORKING BETWEEN INTERNET PROTOCOL (IP) TELEPHONY PROTOCOLS

the specification of which (Title of the Invention)

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) _____ as United States Application Number or PCT International

Application Number _____ and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 356(b) of any foreign application(s) for patent or inventor's certificate, or 356(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
			<input type="checkbox"/>	YES	NO
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.
60/137,867	06/07/1999	

[Page 1 of 2]

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02C attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number OR ☒ Registered practitioner(s) name(s) and registration number listed below

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Richard E. Jenkins	28,428	Gregory A. Hunt	41,085
Arles A. Taylor, Jr.	39,395		

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information on sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label OR ☒ Correspondence address below

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Address	3100 Tower Boulevard		
City	Durham	State	NC
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Country	USA	Telephone	919-493-8000
Fax	919-419-0383		

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any)) Family Name or Surname

David P. Rcss

Inventor's Signature Date 2/17/2000

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Post Office Address 107 Sedgman Court

Post Office Address

City Cary State NC ZIP 27511 Country USA

☒ Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto


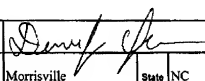
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DECLARATION

ADDITIONAL INVENTOR(S)
 Supplemental Sheet
 Page 1 of 1

Name of Additional Joint Inventor, if any:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Xuewen		Li	
Inventor's Signature		Date	2/17/2000
Residence: City	Cary	State	NC
		Country	USA
		Citizenship	Canadian
Post Office Address	105 Modena Drive		
Post Office Address			
City	Cary	State	NC
		ZIP	27513
		Country	USA
Name of Additional Joint Inventor, if any:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Denise J		Ingram	
Inventor's Signature		Date	2/17/2000
Residence: City	Morrisville	State	NC
		Country	USA
		Citizenship	US
Post Office Address	222 Lake Brandt Drive		
Post Office Address			
City	Morrisville	State	NC
		ZIP	27560
		Country	USA
Name of Additional Joint Inventor, if any:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Gregory Robert		Utas	
Inventor's Signature		Date	
Residence: City	Irving	State	TX
		Country	USA
		Citizenship	Canadian
Post Office Address	215 Edgestone Drive		
Post Office Address			
City	Irving	State	TX
		ZIP	75063-7208
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DECLARATION**ADDITIONAL INVENTOR(S)
Supplemental Sheet**
Page 1 of 1**Name of Additional Joint Inventor, if any:**☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any))

Family Name or Surname

Xuewen

Li

Inventor's
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Date

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Citizenship Canadian

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Country USA

Name of Additional Joint Inventor, if any:☐ A petition has been filed for this unsigned inventor

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Denise J

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Name of Additional Joint Inventor, if any:☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any))

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Gregory Robert

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Inventor's
SignatureFeb 18/00
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